1. Problem Description

Although it is unpopular, fish breeding is an important source of foreign exchange for Sri Lanka. In the middle level it is self-employment for a vast population. Not only that, most of the people also have a home aquarium to refresh their minds. Accordingly, we can conclude that fish breeding has been spread to each level in society.

Temperature of water, pH level and turbidity are the main parameters which the fish breeders should keep on track regarding the safety of their farm. But as we observed, there is no such system deployed to measure these parameters in real time even in mass scale aquariums in Sri Lanka. Hence, this can lead to economic disasters if a parameter change happens. Another problem we can identify is the need of employees for feeding. Commonly, feeding is done once or twice per day. Therefore, if we can automate this process, it would be beneficial for the farm owners.

Several aquarium monitoring systems are available in the global market. The problems we can identify, when we are going to deploy them in Sri Lanka are,

1. High cost (approximately $ 500 per unit for an industrial level equipment)
2. Requirement of periodic service (this is also problematic because no service center located in Sri Lanka)

2. Problem Validation

We visited Angel Aquarium (pvt) Ltd. which is one of mass scale aquarium in Sri Lanka to get a better understanding regarding the problem. As explained in the above section they are also hoping to deploy this kind of system but the initial cost to purchase them from the global market is not affordable for them. This was a huge motivation for our team.

By this discussion, we could gather important information regarding the precious water parameters for fishes and feeding patterns. Another important fact we observed is that the pH level is critical for indoor fish species while the turbidity is the important parameter for the outdoor species. pH level is not critical for outdoor species since they have been adopted for varies pH levels such as rainy water, but the high turbidity can damage their branchia. However, temperature is critical for both indoor and outdoor species.

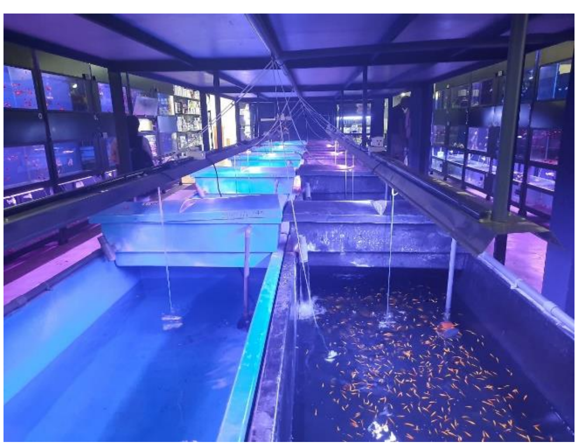


Figure: Indoor tank

Figure: Outdoor tank

3. Solution

Our solution is Aquamate. A monitoring and automation system for mass scale aquariums in Sri Lanka. Our mission is to provide this product in an affordable price.

Under the reasons explained earlier, we introduce two separate units for indoor and outdoor tanks. By this method we can reduce the cost for un-necessary sensors.

Under this project we implement only the indoor unit. Table 1 lists the features each unit has. The feeder is programmable via the dashboard to feed at any time interval.

Table 1: Features of units

Feature	Indoor Unit	Outdoor Unit
Temperature sensor	Yes	Yes
pH sensor	Yes	No
Turbidity sensor	No	Yes
Feeder	Yes	Yes
Dashboard	Yes	Yes

4. Implementation

4.1 Component Selection

Follows are how we selected the critical components of our device.

Micro controller: Selected micro controller is ESP32 wroom 32 considering its WiFi capability and low power usage. ESP8266 is also a good alternative which comes under the same family with low price, however since we need two ADC lines we had to move to ESP32 wroom 32 with the an additional cost.

pH sensor: Gravity: Analog pH Sensor which comes with an industrial level probe is selected considering its considerable accuracy and relative low cost.

Temperature sensor: DS18B20 is selected. It is water resist and has an excellent accuracy.

4.2 Circuit Design and Initial Testing

The device is planned to be powered by a 9V supply. There are two reasons behind this decision

1. If we use 230V AC current to power the device, there has to be a 230V AC current wiring around the aquarium. Since aquariums always deal with water, we decided to power the device with 9V considering the user safety in a case of current leakage.

2. Additionally, it reduces the cost per unit since multiple devices can be powered with a single power supply. No need of adding a transformer and relative circuitry for every device.

There are two voltage regulator ICs inside a device. AMS1117-3.3v regulator is used to power the micro controller and the temperature sensor. AMS1117-5v regulator is used to power the pH sensor and feeder.

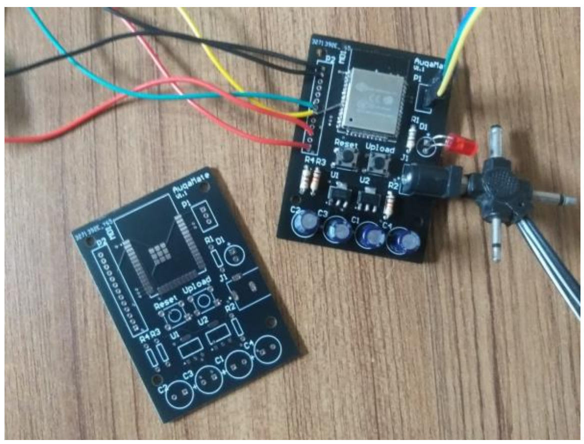
Initial testing was carried out using a ESP32 development kit. A breadboard prototype was implemented to test the sensors. Temperature sensor was tested in our own and pH sensor was tested with the help of department of material science and engineering.

4.3 Printed Circuit Board Design

Printed circuit board was designed with Altium Designer 21.0.8. It was two-layer design. Two push buttons were added on the PCB for testing purposes and can be removed in a mass scale manufacturing.

Manufacturing was done at JLCPCB in China. Therefore, online available JLCPCB design rules were imported to Altium Designer.

Refer Appendix A and Appendix B for schematic diagram and layout respectively.

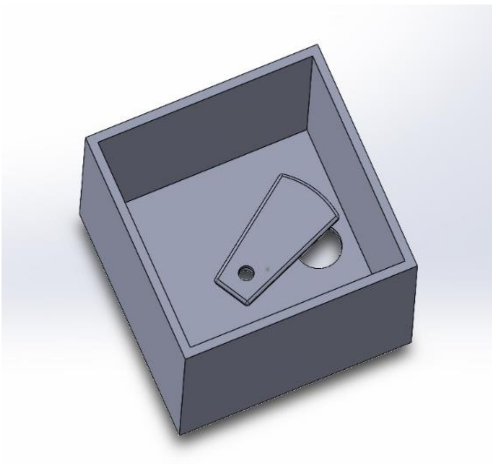


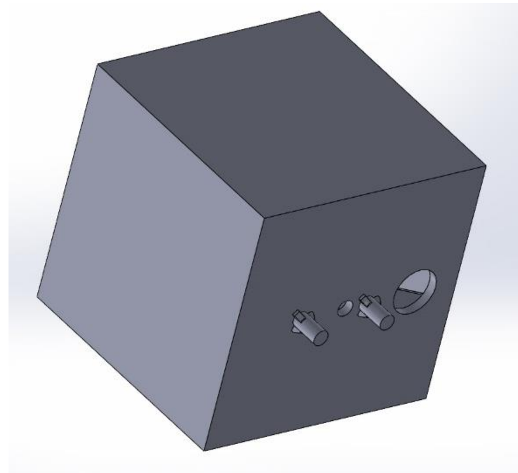
4.4 Enclosure Design

Enclosure design was designed with SOLIDWORKS 2020. There are two main parts such that fish feeder and main PCB container.

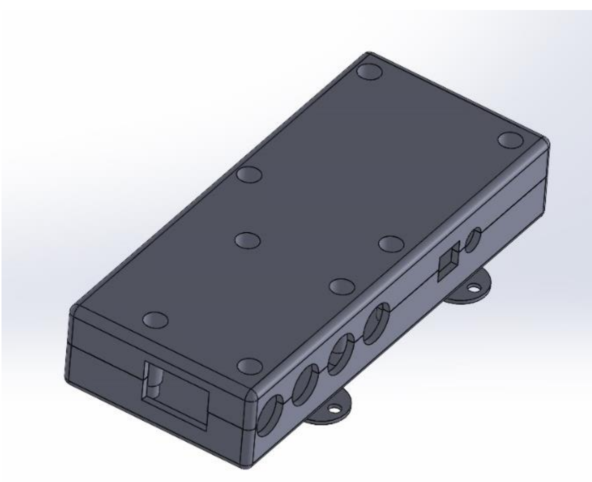
4.4.1 Fish feeder

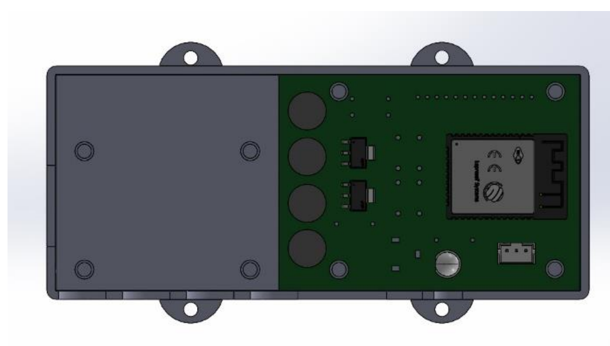
This is a cube shaped box. There is a lid that opens and closes to fall fish seeds into the tank at the specified time interval. There are two mounting bosses in the bottom side to fix the servo motor that is used to open and close the lid.





4.4.2 Main PCB Container
This was designed to contain the main PCB and pH sensor unit. Two circuit parts are fixed to the box using four mounting bosses. There are four holes to fix sensors.

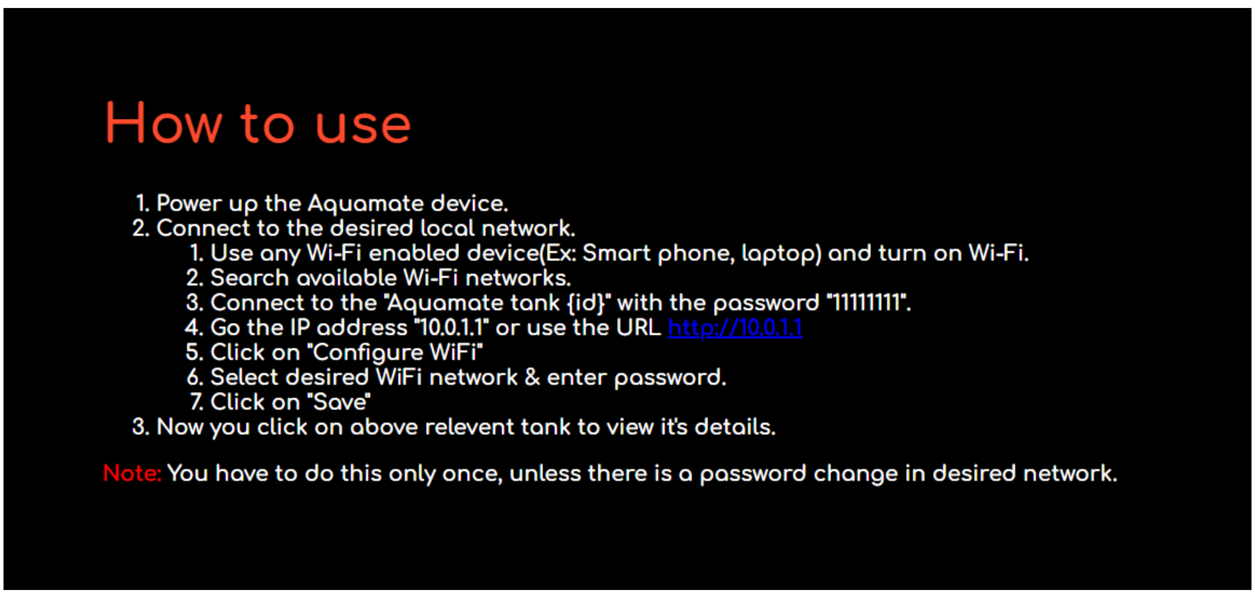




4.5 Web Development
4.5.1 Web Page
Main web site can be accessed by anyone using the link http://aquamate-global.web.app. An image of interface is shown below.

Users can click relevant button with tank name to see the corresponding dashboard. It will pop-up in a new window. But those details can only be accessed by the people who have connected to the same local network, as same network which the Aquamate device is connected.

If the user is powering up the Aquamate device for the very first time, there is a small configuration needs to be done. Those details are shown in the web page as well.

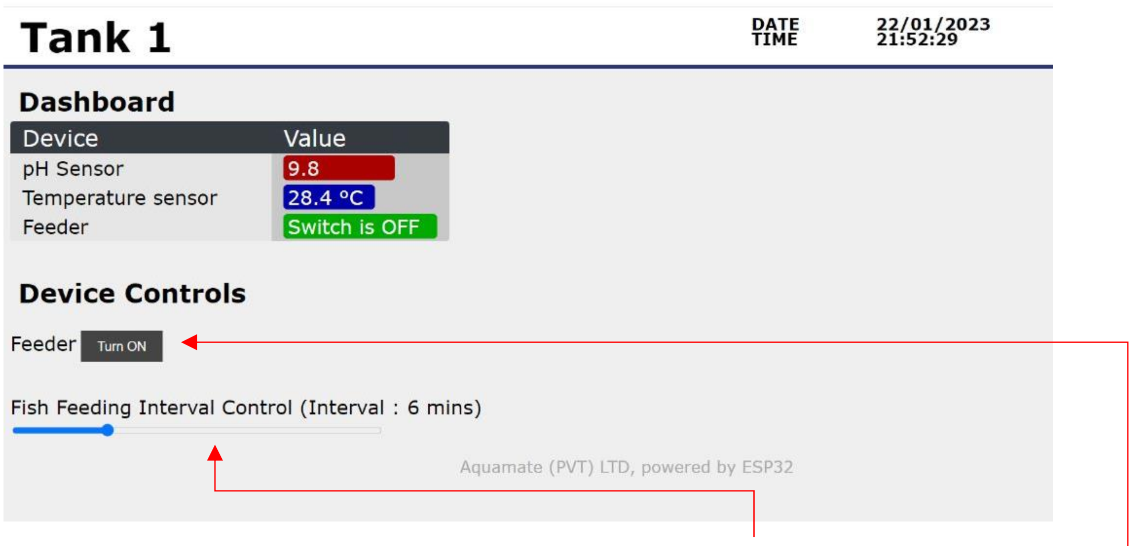


Above steps can be carried out by anyone who has basic knowledge of computer networks. Most importantly, these steps need to be done only once for each device. After that when powering on, Aquamate device will automatically connect to the previously configured local network.

4.5.2 ESP32 Web Server

Each Aquamate device has a web server running inside the ESP32 micro controller. After connected to the local network, it will send real time data of pH value, temperature, feeder on/off status to the web site continuously. So, the users can view the data.

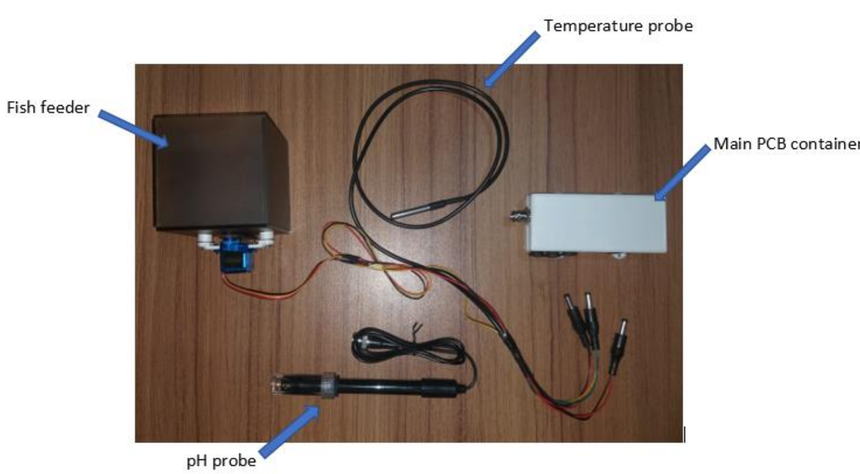
pH progress bar shows pH values from 0 to 14 as standard scale. And temperature progress bar shows temperature values from 0°C to 50°C. If pH value or temperature value is too low or too high, color of the progress bar will change from blue to red. An instance of dashboard of a tank is shown below.



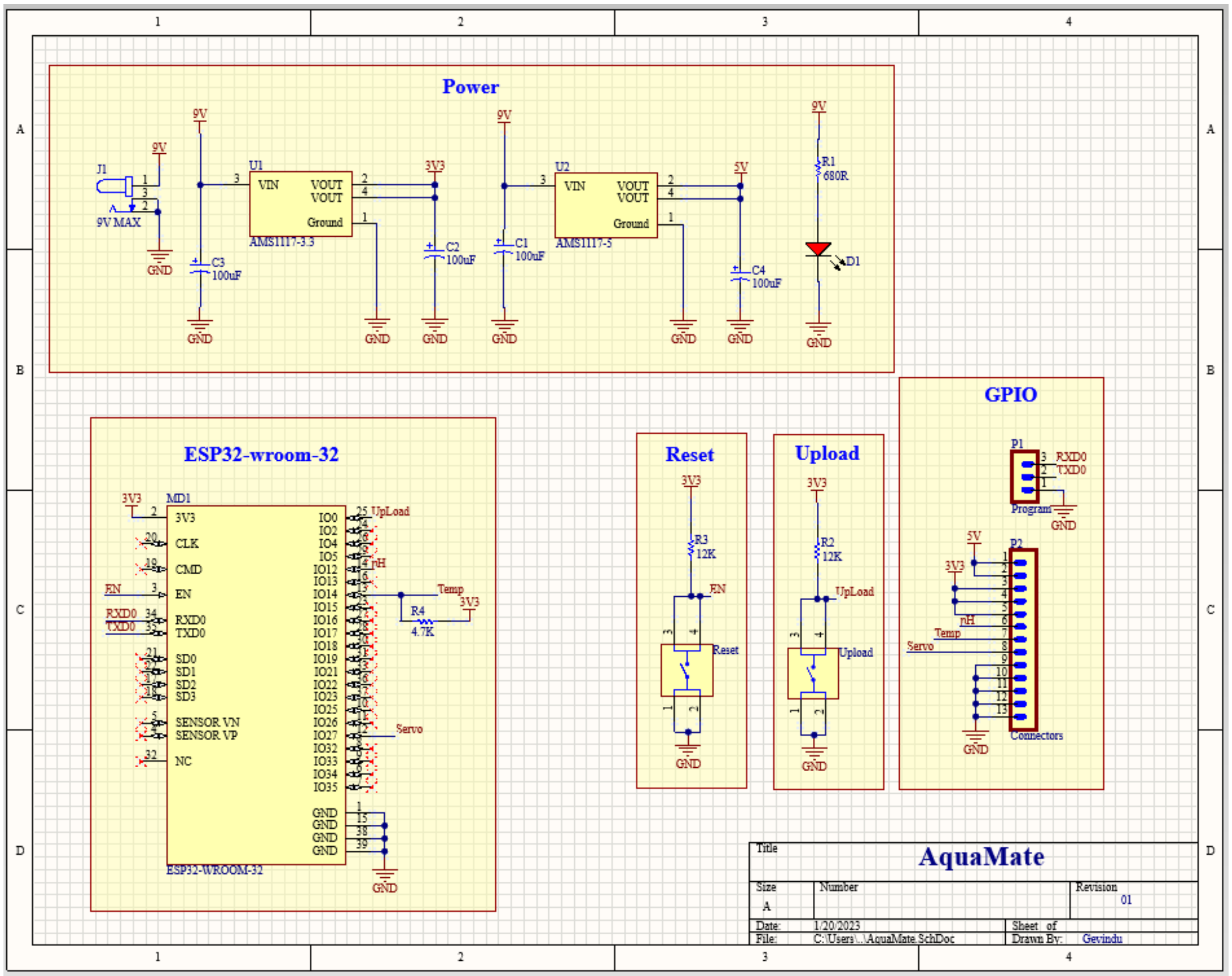
As well as users can set the fish feeding time interval using the slider in web page and feeder on/off switch. Slider can change the fish feeding interval between 1 to 24 hours. Those data will send back to the ESP32 web server and will act accordingly.

4.6 Final Testing

After completing and assembling all components a final testing was carried out to check the overall functionality. Things works perfectly and communicate with the web server without any failure. Figure below shows the parts of Aquamate indoor unit.



Appendix A



Power
9V
J1
9V MAX
GND
U1
VIN
VOUT
VOUT
Ground
AMS1117-3.3
3V3
C3
100uF
C2
100uF
C1
100uF
U2
AMS1117-5
5V
C4
100uF
R1
680R
D1
ESP32-wroom-32
MD1
3V3
CLK
CMD
EN
RXD0
TXD0
SD0
SD1
SD2
SD3
SENSOR VN
SENSOR VP
NC
UpLoad
pH
Temp
R4
4.7K
Servo
ESP32-WROOM-32
Reset
R3
12K
Upload
R2
12K
GPIO
P1
Program
P2
Connectors
Title
AquaMate
Size
A
Number
Revision
01
Date:
1/20/2023
File:
C:\Users\..\AquaMate.SchDoc
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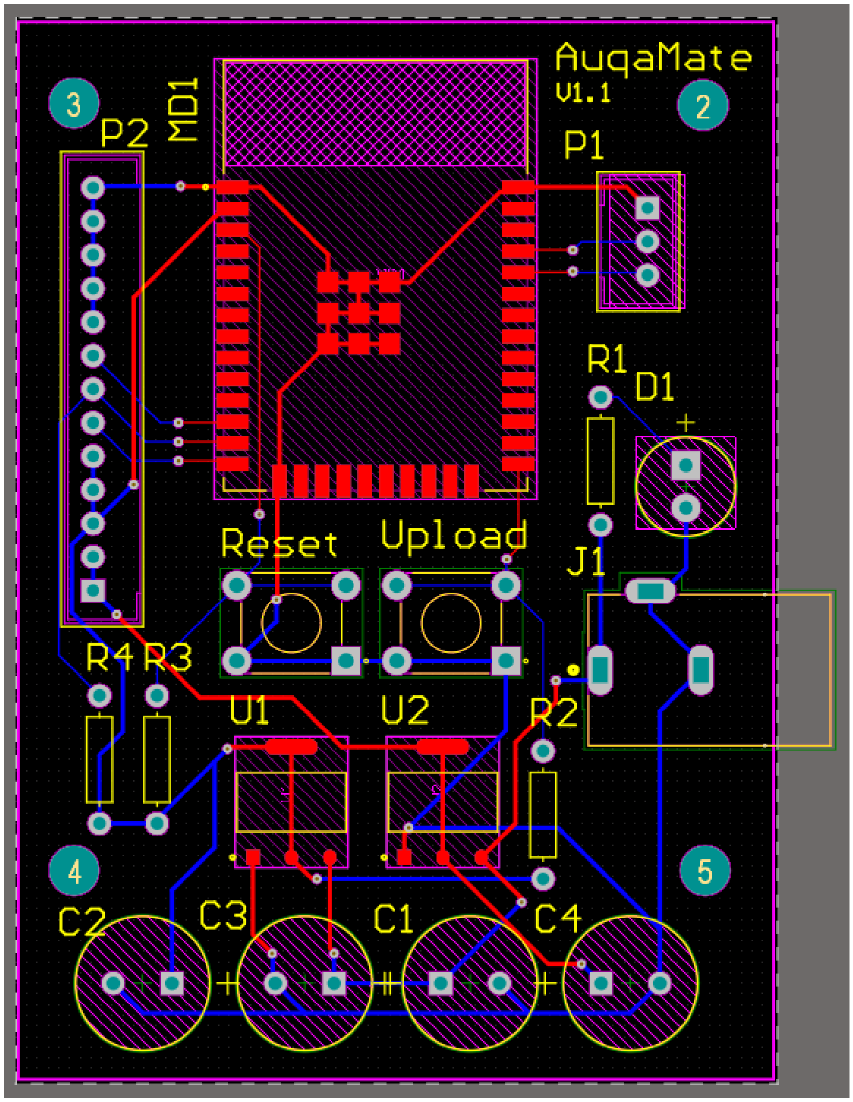
Appendix B


AuqaMate
V1.1
3
2
4
5
P2
MD1
P1
R1
D1
Reset
Upload
J1
R4
R3
U1
U2
R2
C2
C3
C1
C4